

Fatigue, Schedules, Sleep, and Sleepiness in U.S. Commercial Pilots During COVID-19

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- INTRODUCTION:** COVID-19 has had a significant impact on the aviation industry. While reduced flying capacity may intuitively translate to reduced fatigue risk by way of fewer flights and duty hours, the actual impact of the pandemic on pilot fatigue is unknown.
- METHODS:** We surveyed U.S. commercial airline pilots in late 2020 ($N = 669$) and early 2021 ($N = 156$) to assess the impact of COVID-19 on schedules and fatigue during the pandemic.
- RESULTS:** Overall, pilots reported reduced flight and duty hours compared to prepandemic. Average sleep on workdays was slightly shorter in late 2020 (6.87 ± 1.14 h) and recovered to prepandemic levels in early 2021 (6.95 ± 1.11 h). Similarly, the frequency of sleepiness on days off and in-flight increased in late 2020, with 54% of pilots reporting an increase in in-flight sleepiness, then returned to prepandemic levels in early 2021. The use of in-flight sleepiness countermeasures remained the same across assessed time points. Pilots highlighted several factors which impacted their sleep and job performance, including limited access to nutritional food during duty days and layovers, reduced access to exercise facilities during layovers, increased stress due to job insecurity and health concerns, increased distractions and workload, and changes to scheduling.
- DISCUSSION:** Despite a reduction in flights and duty days, COVID-19 led to increased sleepiness on days off and in flight, potentially due to the negative impact of lack of access to essential needs and heightened stress on sleep. Operators need to monitor the change in these COVID-19 related risks as the industry returns to full service.
- KEYWORDS:** coronavirus, aviation, countermeasures, survey, return-to-service.

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The COVID-19 global pandemic has had the most significant impact on the aviation industry of any event in the past 40 yr.⁵ In May 2020, domestic flights were reduced by 74% in the United States compared to the same time in 2019.² By November 2020, flights had recovered to just over 50%, but then remained at this level through February 2021.⁴ It might be expected that fewer flights result in shorter, fewer duty days and, therefore, increased rest opportunities and reduced fatigue for pilots. However, the unique operational impacts on scheduling, combined with a smaller workforce due to voluntary leave, early retirement, and furlough,³ mental health challenges,⁶ and changes to the daily experience of being a pilot, have had an unknown impact on pilot sleep, sleepiness, and performance. Indeed, fatigue reports in the European Union were higher in April-May 2020 than the previous 3-yr average, highlighting fatigue issues despite the industry almost grinding to a halt.¹¹

Prepandemic, fatigue was a known issue in aviation, with several surveys and in-flight studies showing elevated fatigue associated with long duties, early starts, late finishes, night flights, changes in circadian timing, and higher workload.⁸ Understanding how the pandemic has interacted with these factors to create a new fatigue landscape is important to: 1) support the aviation industry in managing current reduced operations; 2)

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help in the transition back to normal operations; and 3) provide a roadmap of how to prepare for events in the future. Early in the pandemic, the European Union Aviation Safety Agency (EASA)¹² and the International Federation of Air Line Pilots' Associations (IFALPA)¹⁹ released position statements on fatigue management during COVID-19 in recognition of the anticipated unique threats and challenges being faced both during the pandemic and looking ahead to return to service. While these collaborative groups of experts identified potential hazards, the same experts recommended that organizations collect data during this period to identify unforeseen risks and quantify the impact of projected challenges. Using a large cross-sectional survey and longitudinal approach in a subset of respondents, we aimed to explore how changes in aviation due to the COVID-19 pandemic influenced schedules, sleep, and sleepiness in U.S. commercial pilots.

METHODS

Subjects

The study protocol was approved in advance by the San José State University Human Subjects Institutional Review Board (Protocol Number: 20231). Each subject provided informed, anonymous consent by checking a box online before participating in the survey. All commercial pilots operating in the United States were invited to participate in the survey. Non-pilot aviation personnel were ineligible. Invitations were sent via safety and fatigue newsletters distributed by third parties or directly through airline communications. The survey was hosted on Qualtrics. Pilots who consented were provided a unique, random 6-digit identification code to be used to link responses across subsequent surveys.

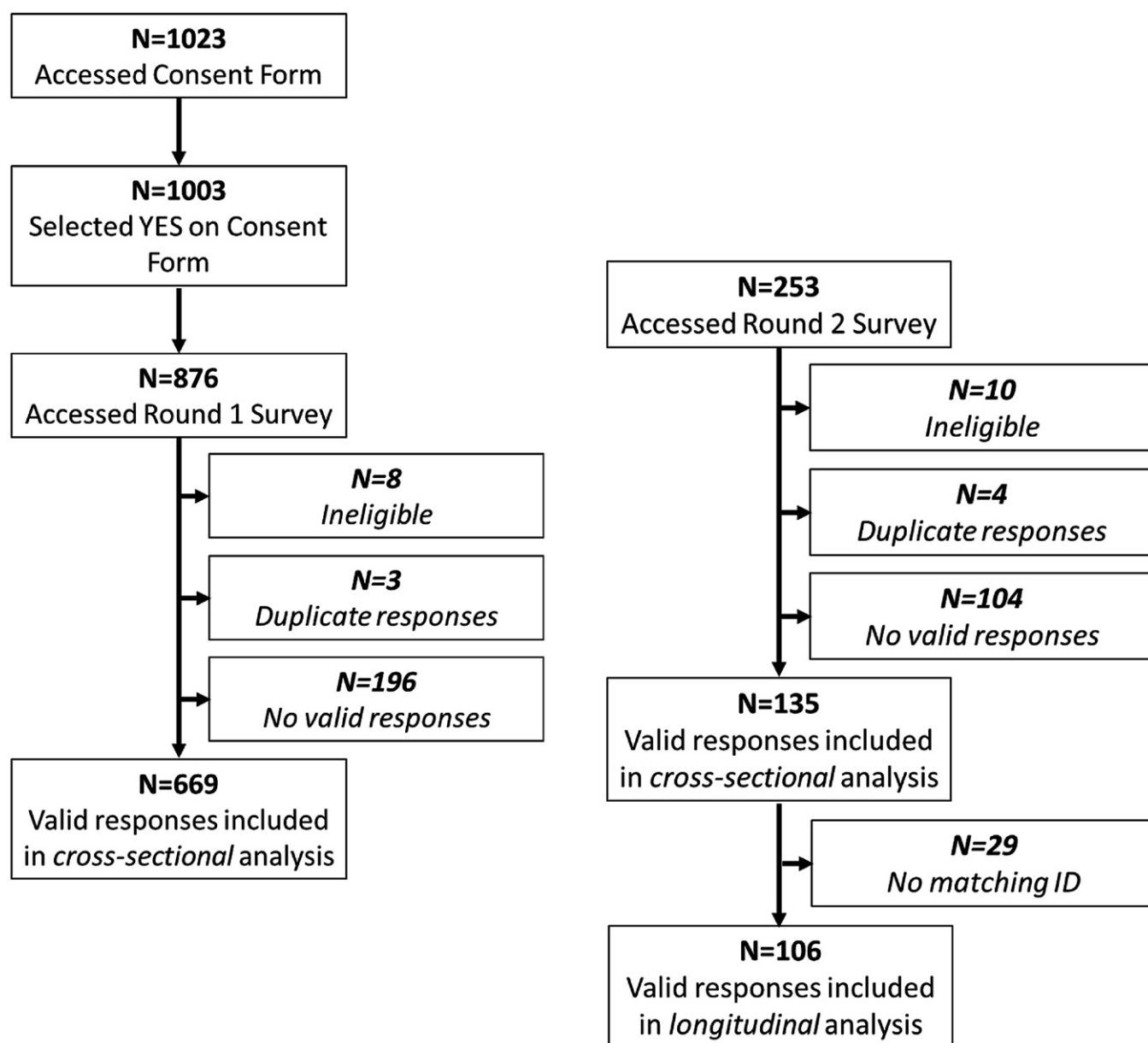


Fig. 1. CONSORT flow diagram of Round 1 (left) and Round 2 (right) survey responses.

Procedure

For each question, pilots were asked to respond considering their experiences: 1) prior to the impact of COVID-19 on the aviation industry; and 2) in the past month. Responses to Round 1 were collected between October 15, 2020, and December 7, 2020 ("Late 2020"). Responses to Round 2 were collected between January 25, 2021, and March 10, 2021 ("Early 2021"). The survey was developed through a series of consultations with stakeholders, including pilots, unions, and fatigue working groups. The Round 2 survey included Round 1 questions as well as additional questions based on common themes arising in the comments section of Round 1. All survey questions were non-compulsory. A copy of each survey is available upon request.

Statistical Analysis

Descriptive statistics were assessed using paired Student's *t*-tests for continuous variables and Wilcoxon signed-rank tests for ordinal scales to compare variables of interest. A negative binomial mixed-effects model with a random effect of subject (intercept) was used to compare frequency data.

RESULTS

Over 80% of responses were collected within the first month of the survey opening in both rounds. The consent form for the

study was accessed 1023 times; 669 pilots provided valid responses to Round 1. Round 2 data collection resulted in 135 valid responses, 106 of which could be linked to Round 1 responses (see **Fig. 1** for a CONSORT diagram of included/excluded survey responses for Round 1 and Round 2).

Respondents to Round 1 included captains (47%) and first officers (52%), who were predominantly men (91%) and flew passenger operations (83%) with an average of 21 yr of commercial flying experience (see **Table I** for full demographics). The subset of linked Round 2 responses had a similar demographic distribution, but with a greater proportion of First Officers (64%) and passenger operations (91%) compared to Round 1. Due to the less evenly distributed positions and operations, combined with fewer respondents in Round 2, analyses comparing responses across these categories are only shown for the Round 1 dataset.

On average, pilots reported a decrease in the total number of flight hours and duty days worked per month during the pandemic [Prepandemic vs. Late 2020 flight hours: $t(488) = 10.930$, $P < 0.001$, $d = 0.496$; duty days: $t(488) = 10.790$, $P < 0.001$, $d = 0.488$; Prepandemic vs. Early 2021 flight hours: $t(81) = 6.275$, $P < 0.001$, $d = 0.693$; duty days: $t(81) = 4.981$, $P < 0.001$, $d = 0.550$; **Fig. 2A**). However, examining trends within respondents (Round 1, Late 2020 data only), approximately one-quarter of respondents reported an increase in duty days and flight hours in late 2020 relative to prepandemic. Seat position did not appear to influence reported flight hours and duty days; however, pilots

Table I. Demographics of Survey Respondents.

	ROUND 1		ROUND 2	
	N	% RESPONSES	N	% RESPONSES
Total number of valid responses	669	--	106	--
Position				
Captain	264	46.8	36	34.0
First Officer	294	52.1	68	64.2
Other	6	1.1	2	1.9
Operation				
Passenger	469	83.3	96	90.6
Cargo	52	9.2	6	5.7
Both	42	7.5	4	3.8
Gender				
Male	512	90.8	93	87.7
Female	44	7.8	12	11.3
Other/ Prefer not to say	8	1.4	1	0.9
Household				
Partner/Spouse	493	87.4	88	83.0
Roommates/Parents	11	2.0	2	1.9
Alone	60	10.6	16	15.1
Children	295	52.7	59	55.7
Children < 6yo	69	12.3	12	11.3
Chronotype				
Definitely morning	108	19.1	15	14.2
More morning	203	36.0	44	41.5
More evening	179	31.7	35	33.0
Definitely evening	74	13.1	12	11.3
	AVERAGE	SD (RANGE)	AVERAGE	SD (RANGE)
Total lifetime flying hours	14,551.7	7310.1 (1550-60,000)	13,374.8	6704.7 (2000-28,000)
Years as a commercial pilot	20.8	10.1 (0.5-41)	19.2	10.4 (0.5-41)
Years at current airline	15.0	11.0 (0.1-37)	13.7	11.2 (0.4-36)
Years in current position	6.7	6.5 (0.1-30)	6.2	6.3 (0-29)
Age	51.2	8.7 (25-64)	50.2	9.0 (29-64)

Demographics only available for Round 2 respondents with linked data. Percent responses are based on the total number of respondents for each question.

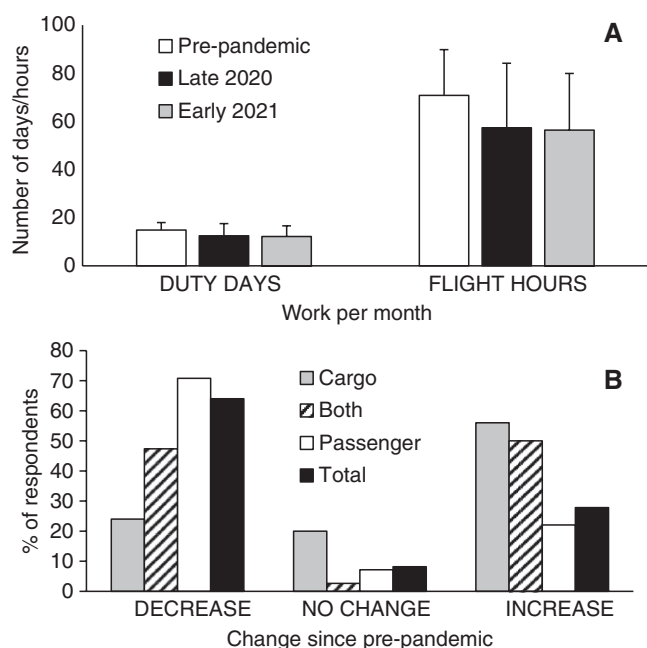


Fig. 2. A) Mean (\pm SD) number of duty days and flight hours worked per month Pre-pandemic, Late 2020 (Round 1), and Early 2021 (Round 2). Duty Days response numbers: Pre-pandemic, $N = 671$; Late 2020, $N = 497$ ($N = 90$, no flights this month); Early 2021, $N = 80$ ($N = 26$, no flights this month). Flight hours response numbers: Pre-pandemic, $N = 668$; Late 2020, $N = 495$ ($N = 90$, no flights this month); Early 2021, $N = 80$ ($N = 27$, no flights this month). B) Change in monthly flight hours worked during Late 2020 relative to Pre-pandemic based on operations flown.

flying cargo operations were more likely to report an increase or no change in duty days and flight hours compared to those only flying passenger operations (Fig. 2B). (See Fig. A1 online, <https://doi.org/10.3357/AMHP.6031sd.2022>, for the distribution of flight and duty durations.)

In the free response section, 32% ($N = 89$) of Round 1 comments raised fatigue concerns related to schedule changes due to the pandemic, including: an increase in the number of flights per duty, long sits/ground time between flights, increased unpredictability and schedule changes, shorter layovers reducing time for sleep, and shifts with later duty starts/ends. For some, the trend for schedules to shift to later flights was viewed as beneficial, while others saw it as a disruption to their usual schedule and circadian rhythm. The selected comments below highlight some of these factors.

“Before COVID-19 the schedules were fairly consistent in regards of reporting time, length of trip, layovers, etc. Since COVID-19 the schedules are all over the place with widely different reporting times within a trip, lots of last-minute changes, lots of sitting around in airports waiting for the next flight leg.”

“Duty days have gotten longer with more planned, mid-sequence sit time which always affects alertness toward the end of that day.”

“The second biggest contributor [to fatigue] having been jumping from my normal routine of morning flying to having to fly well into the night.”

“Fewer early morning departures after the onset of COVID has resulted in less fatigue and better rest.”

Sleep, Sleepiness, and Countermeasures

Respondents were asked to estimate their sleep need, amount of sleep obtained on days off, and amount of sleep obtained on workdays prior to and during the pandemic. Responses were cleaned for outliers (>3 standard deviations from the mean; $N = 38$ data points removed, equivalent to $<1\%$ of the data).

There was a slight increase in self-reported sleep need and decrease in sleep obtained during workdays in late 2020 compared to prepandemic [sleep need: $t(474) = -7.76$, $P < 0.001$, $d = 0.356$; workdays: $t(465) = 2.13$, $P = 0.035$, $d = 0.099$; Fig. 3A], but these values returned to prepandemic levels in early 2021. Sleep duration was shorter on workdays compared to sleep need and sleep on days off across all data collection periods [Prepandemic: vs. sleep need, $t(481) = -16.5$, $P < 0.001$, $d = -0.753$; vs. days off, $t(480) = -20.8$, $P < 0.001$, $d = -0.949$; Late 2020: vs. sleep need, $t(466) = 17.9$, $P < 0.001$, $d = -0.829$; vs. days off, $t(463) = -18.1$, $P < 0.001$, $d = -0.839$; Early 2021: vs. sleep need, $t(81) = -6.36$, $P < 0.001$, $d = -0.702$; vs. days off, $t(81) = -6.00$, $P < 0.001$, $d = -0.663$]. Examination of trends within respondents in the Round 1 (Late 2020) data revealed that the majority reported no changes in sleep on days off (67%) or workdays (60%), with the remaining responses split between reporting an increase or decrease in total sleep (see Fig. A2 online, <https://doi.org/10.3357/AMHP.6031sd.2022>; Fig. A3 displays sleep quality on the aircraft during layovers).

When asked, “How often did you have trouble staying awake while driving, eating meals, or engaging in social activity?” (an item from the Epworth Sleepiness Scale), the proportion of pilots reporting symptoms at least once or twice a week increased in late 2020 (30%) relative to prior to the pandemic (13%) [$W = 3237$, $P < 0.001$, rank biserial correlation (r_{rb}) = -0.690], but returned to prepandemic levels in early 2021 (12%) ($W = 294$, $P = 0.511$, $r_{rb} = -0.117$; Fig. 3B). Indeed, 32% of pilots increased their frequency of sleepiness on days off in late 2020 (see Fig. A4 online, <https://doi.org/10.3357/AMHP.6031sd.2022>, for the breakdown across seat position and operations).

On average, respondents reported that prior to COVID-19 they experienced fighting sleepiness on the flight deck on 16% of flights. In late 2020, this increased to 21% of flights, but then dropped back to 15% of flights in early 2021 [Prepandemic vs. Late 2020: $\chi^2(1) = 4.56$, $P = 0.033$; Prepandemic vs. Early 2021: $\chi^2(1) = 0.036$, $P = 0.849$; Fig. 3C]. In late 2020, 43% of respondents ($N = 206$) reported an increase in the proportion of flights on which they experienced sleepiness since the pandemic. There was no apparent difference across seat position or carrier type (see Fig. A4 online, <https://doi.org/10.3357/AMHP.6031sd.2022>). Approximately half of the respondents in early 2021 (54%, $N = 46$) reported less frequent in-flight sleepiness than prior to the pandemic; however, 29% ($N = 25$) still reported elevated in-flight sleepiness frequency relative to prepandemic levels. Changes in early 2021 should be interpreted with caution given the low sample size.

For those who reported experiencing sleepiness in flight, the most popular in-flight countermeasures were caffeine and

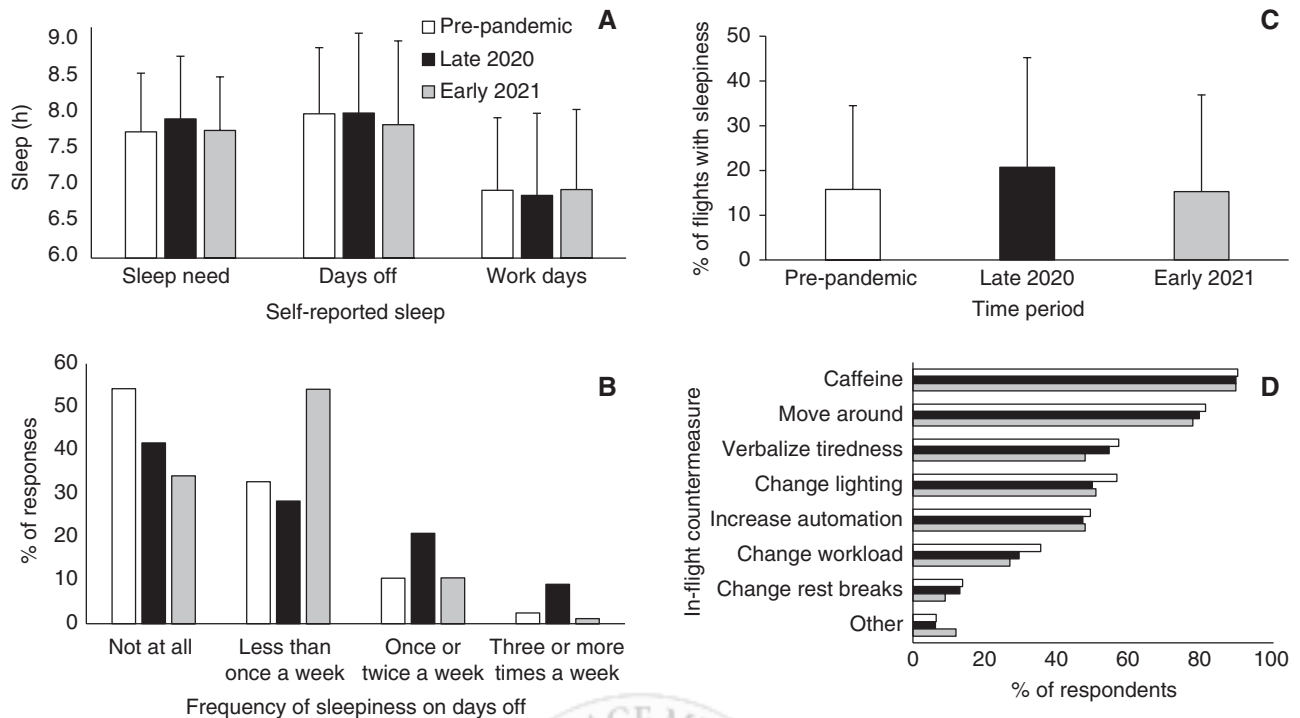


Fig. 3. A) Self-reported sleep prior to and during the pandemic (mean \pm SD). Response numbers: Prepandemic sleep need, $N = 622$; Prepandemic days off, $N = 617$; Prepandemic work days, $N = 617$; Late 2020 sleep need, $N = 563$; Late 2020 days off, $N = 558$; Late 2020 work days, $N = 472$; Early 2021 sleep need, $N = 107$; Early 2021 days off, $N = 107$; Early 2021 work days, $N = 80$. B) Frequency of having trouble staying awake while driving, eating meals, or engaging in social activity prior to and during the pandemic. Response numbers: Prepandemic, $N = 485$; Late 2020, $N = 484$; Early 2021, $N = 85$. C) Percentage (\pm SD) of flights on which pilots experienced fighting sleepiness prior to and during the pandemic. Response numbers: Prepandemic, $N = 624$; Late 2020, $N = 486$ ($N = 80$, did not fly this month); Early 2021, $N = 85$ ($N = 22$, did not fly this month). D) Percentage of respondents using in-flight countermeasures prior to and during the pandemic. Response numbers: Prepandemic, $N = 573$; Late 2020, $N = 384$; Early 2021, $N = 67$.

moving around (Fig. 3D). Respondents were also asked how often they used each in-flight fatigue countermeasure. Caffeine use remained the most commonly used countermeasure on approximately two-thirds of flights, followed by increased use of automation. There was no significant difference in the frequency of countermeasure use during the pandemic compared to prepandemic. Note that early 2021 responses may be distorted due to the low number of respondents. There were 16 'other' in-flight countermeasures reported, the most popular of which were: engaging in conversation with crew ($N = 13$ prior to, $N = 11$ during pandemic), eating ($N = 5$ prior to, $N = 7$ during pandemic), and napping in the cockpit ($N = 6$ prior to, $N = 4$ during pandemic).

Pandemic-Related Factors Affecting Sleep, Fatigue, and Job Performance

Several main themes relating to pandemic-specific factors affecting fatigue were raised in the comments section of Round 1 and further explored in Round 2. Below is a summary of each theme. Further details on comments can be found in the online appendix (<https://doi.org/10.3357/AMHP.6031sd.2022>).

Access to nutritional food. A common topic raised by respondents in the Round 1 comments section in late 2020 referred to the lack of available nutritious food on the aircraft, at airports, at hotels, and on layovers (26% of comments, $N = 72$). This was largely driven by local state and country mandates which led to

the closure of many restaurants in airports and enforced quarantine at layover hotels. Difficulty in finding food led to pilots going without meals for entire duty periods and reduced sleep opportunities when trying to find food on layovers.

Prior to the pandemic, approximately one-third of respondents (35%, $N = 47$) had difficulty accessing nutritional food between flights or during domestic and international layovers. In early 2021, this significantly increased to nearly double (61%, $N = 81$; $W = 655$, $P < 0.001$, $r_{tb} = -0.633$). Of those who reported having difficulties, prior to the pandemic 83% ($N = 39$) experienced this on 'one or two', or 'some but not all' duties compared to the past month in which 40% ($N = 32$) experienced this on 'almost every' duty. Of the sample, 80% reported an increase in the frequency of this experience (Fig. 4).

When asked how often the lack of access to nutritional food had impacted their sleep prior to the pandemic compared to in the past month, pilots reported a significant increase in the frequency of impact ($W = 599$, $P < 0.001$, $r_{tb} = -0.640$). Prior to the pandemic, 10% reported that lack of food access 'sometimes' or 'almost always' impacted sleep, compared to 32% in early 2021. Similarly, respondents felt that lack of access to food significantly impacted on their ability to do their job safely relative to prepandemic, with 33% reporting impact 'sometimes' or 'almost always' in the past month ($W = 305$, $P < 0.001$, $r_{tb} = -0.707$). The comment below highlights common food availability issues experienced by pilots during duty days and layovers.

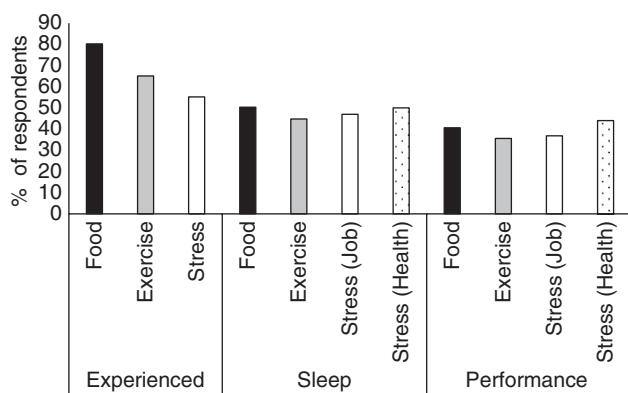


Fig. 4. Percentage of respondents reporting an increase from Prepandemic to Early 2021 in: A) the frequency of experiencing each factor (Experienced), B) the impact of each factor on their sleep (Sleep), and C) the impact of each factor on their ability to perform their job safely (Performance).

“Lack of food sources on layovers is problematic. On more than one occasion I’ve had nothing to eat for an entire day. Also, the availability of food at airports is spotty and difficult to obtain, due to long lines at the facilities that are open, and the limited time between flights. Crew meal availability during flights is not dependable and the food is repetitive, bland, and non-nutritious.”

Access to exercise facilities. Similar to the lack of food availability at layover hotels, some pilots also mentioned that gyms were closed and some countries did not allow residents to leave the hotel room itself, limiting access to fresh air and outdoor exercise. Prior to the pandemic, pilots performed an average of 54.1 min (SD 35.4, range 0–180) of moderate to high intensity exercise on layovers. In the past month, this had halved to an average of 27.8 min [SD 30.6, range 0–180; $t(105) = 9.45$, $P < 0.001$, $d = 0.918$], with 65% reporting a reduction in the time spent exercising on layover.

When asked how often the lack of access to exercise facilities impacted sleep prior to the pandemic compared to early 2021, 45% of respondents reported an increase in the frequency of impact. Prior to the pandemic, 12% reported that lack of access to exercise facilities ‘sometimes’ or ‘almost always’ impacted sleep; this significantly increased to 44% in early 2021 ($W = 577$, $P < 0.001$, $r_{rb} = -0.606$). Respondents felt that lack of access to exercise facilities impacted on their ability to do their job safely more often in early 2021 compared to prepandemic ($W = 1425$, $P < 0.001$, $r_{rb} = -0.821$), with 28% reporting it had impacted ‘sometimes’ or ‘almost always’ in early 2021. Below is a comment from a pilot describing their experience and how it affected their sleep.

“My increase in fatigue is due to lack of activity. In many locations we are not allowed to leave the hotel to walk or run or just to get fresh air and a hot meal. Additionally, not being able to work out in most fitness facilities means I am out of shape and my sleep is less restful.”

Stress. Several pilots commented on increased stress both personally and observed in their fellow crewmembers (32% of

comments from both surveys combined, $N = 109$). Notable stressors included job insecurity, health concerns, new regulations, and interactions with fellow crewmembers and passengers. Some pilots also mentioned that stress and sleep disruption was exacerbated by having to homeschool children. The additional stress created by the pandemic kept pilots awake at night and made it harder to focus on their work. Further, the stress of potentially being furloughed drove some pilots to increase their flying hours in order to prepare for future reduced income.

Prior to the pandemic, less than one-quarter of pilots (22%) reported feeling nervous or stressed at least ‘sometimes’. In early 2021, this frequency significantly increased, with approximately one-third having felt stressed ‘fairly’ or ‘very’ often (30%), and a further third ‘sometimes’ feeling stressed (34%; $W = 90$, $P < 0.001$, $r_{rb} = -0.942$). Overall, 55% of respondents reported an increase in the frequency of feeling stressed.

When asked how often stress impacted sleep prior to the pandemic compared to in early 2021, 47% of respondents reported an increase in the frequency of impact related to job insecurity, and 50% reported an increase related to health concerns (personal and family). Prior to the pandemic, 5% and 11% reported that job stress and health stress, respectively, ‘sometimes’ or ‘almost always’ impacted sleep, compared to 38% and 43% in the past month, representing a significant increase in frequency (job stress: $W = 111$, $P < 0.001$, $r_{rb} = -0.905$; health stress: $W = 229$, $P < 0.001$, $r_{rb} = -0.844$). In early 2021, up to one-third of pilots rated stress as ‘sometimes’ or ‘almost always’ impacting job performance, which was a significant increase from prepandemic ($W = 167$, $P < 0.001$, $r_{rb} = -0.791$; health stress: $W = 201$, $P < 0.001$, $r_{rb} = -0.824$). The comments below highlight the range of stressors faced by pilots during the pandemic and the varying impacts they had on schedules, sleep, and job performance.

“Stress has increased immeasurably during the COVID crisis and that more than [sic] anything contributes to fatigue. We don’t know how long we’ll be employed, nothing is certain, we’re on a new aircraft that we can’t get enough flight time on to truly be proficient, nothing is standard about our operation anymore. So I may not fly as much as I used to but I am far more tired and that fatigue goes far deeper than [sic] the physical.”

“The threat of furlough, due to the pandemic and resulting economic downturn, weighs more heavily than any other single factor. From picking up more trips, to flying any trip (morning or evening) as long as it fits legally into my schedule, I find myself totally absorbed with increasing my ‘furlough fund’ in order to make it through any upcoming potential furlough.”

Distractions and workload. Related to stress, increased distractions and workload associated with COVID regulations were also common topics in the comments (24% of comments from both surveys combined, $N = 79$). Several respondents raised the issue of increased workload due to extra precautions, checklists, wearing masks, and additional briefings, which they felt

Table II. Changes to Professional Status and Training Due to COVID-19 by Seat Position in Late 2020.

SINCE COVID-19 HAVE YOU:	% YES (N)					
	CAPTAINS	FIRST OFFICERS	CARGO	BOTH	PASSENGER	ALL
Been displaced or involuntarily moved from your pre-COVID-19 aircraft?	8.0 (21)	17.3 (51)	1.9 (1)	14.3 (6)	14.1 (66)	12.9 (73)
Been displaced or involuntarily moved from your pre-COVID-19 CA seat to an FO position?	1.1 (3)	5.1 (15)	3.8 (2)	0.0 (0)	3.6 (17)	3.4 (19)
Lost currency due to a reduction in flying hours?	20.2 (53)	34.8 (102)	3.8 (2)	31.0 (13)	30.0 (140)	27.7 (156)
Lost currency from being unable to get recurring training due to a facility shut down?	8.0 (21)	8.5 (25)	3.8 (2)	4.8 (2)	9.0 (42)	8.3 (47)
Started flying cargo operations due to lack of passenger flights?	9.5 (25)	19.4 (57)	11.5 (6)	50.0 (21)	12.2 (57)	14.9 (84)
Been furloughed?	0.4 (1)	6.5 (19)	1.9 (1)	4.8 (2)	3.6 (17)	3.6 (20)

Respondents could select yes to more than one event. 'All' column includes responses that may not have responded to the seat position question and, therefore, may not be the sum of the other two columns.

contributed to fatigue and distractions in the cockpit. Together with added stress, the extra processes and constant changing of rules and regulations in each city and country has been exhausting for many pilots. Some suggested that this was a safety hazard as pilots were less able to focus on the job at hand. The extra processes also cut into rest time; for example, delays to hotel shuttles, having to complete questionnaires upon arrival, and sanitizing the hotel room before use.

"COVID-19 issues are a significant additive condition to risk management in the cockpit, mainly in the form of distractions. COVID-19 issues come up in conversation on almost every single flight, often between work groups as well as between pilots (e.g., pilots and flight attendants, operations agents, provisioning agents, etc.). I often see items missed in flows and/or briefings because individuals are thinking about issues stemming from COVID-19 including security and TSA issues, hotel and restaurant restrictions and issues, and the latest rumors about COVID-19 effects on our industry."

"The ENTIRE process has become MORE EXHAUSTING. Security takes longer and added COVID questionnaires, apps, and screenings detract from the ability to actually commence the layover."

"Since the start of COVID-19 a LOT of additional time has been needed from me to keep up with additional company memos, changes in the industry, planning for displacements, commute, etc... It is not just hours at work that have increased but also hours spent off-duty to keep up with work and COVID-19 implications."

Impact of COVID-19 on Professional Status and Training

Respondents were asked whether they had experienced certain situations due to the impact of COVID-19. In late 2020, approximately one-third of respondents had lost currency due to either a reduction in flying hours and/or limited access to training facilities (Table II). Comparing across seat positions, it appears that first officers were more affected by displacements and lost currency due to the pandemic than captains. In terms of carrier type, cargo pilots were less affected by displacements, lost currency, and furloughs than passenger pilots. Following

up in early 2021 in a subset of respondents, less than 4% reported further disruptions, but it is unclear from the data whether disruptions from late 2020 persisted or were resolved.

DISCUSSION

We are the first to report on the impact of COVID-19 on the schedules, fatigue, sleep, and sleepiness of U.S. commercial pilots during the COVID-19 pandemic. As expected, monthly flight and duty hours were reduced. Despite this, a modest reduction in sleep on work days and increased sleepiness on both days off and in flight were reported. These changes may have been associated with the impact of reduced access to essential needs (e.g., nutrition and exercise) and increase in stress and distractions due to COVID-19 protocols, job insecurity, and health concerns. While some of these impacts appeared to be returning to prepandemic levels, others persisted into early 2021. Our findings suggest that there are several key issues that need to be addressed in order to promote alertness, health, and well-being among commercial pilots in the United States.

While overall changes in flight and duty hours appeared favorable (e.g., fewer hours) or showed little change (e.g., same distribution of flight and duty lengths), pilots commented that changes to shift timing, predictability, and structure were associated with fatigue. For example, pilots reported a trend in later duty start and end times during the pandemic. Late duty finish times are associated with higher fatigue²¹ and became a problem for some pilots, while others enjoyed the relief of later start times relative to early morning starts, which are also known to reduce sleep opportunity.¹⁴ Knowing a shift schedule ahead of time is important for planning sleep. The unpredictability inherent in scheduling during the pandemic led to last minute changes to schedules and subsequent fatigue in some respondents. Long sits between flights in the crew room may lead to underload and extended duty hours, resulting in increased fatigue ahead of subsequent flights.¹¹ Similarly, rapid switching between periods of no work and high workload can be problematic and difficult to adjust to.¹¹ These factors may have contributed to the increase in in-flight sleepiness captured in this survey.

Early in the pandemic, IFALPA¹⁹ recommended scheduling changes such as augmenting crews and reducing scheduled

flight duty periods to allow for delays due to new procedures and crew changes due to positive COVID-19 tests. We did not see any changes in crew complement nor duty length in our data, suggesting that these strategies were not regularly implemented in the United States.

On average, self-reported sleep duration on workdays was reduced, albeit modestly, in late 2020. We also observed a reduction in sleep duration on workdays compared to days off and sleep need, which was consistent across all time periods and reflective of previous reports of sleep on duty days.¹⁶ The group level small reduction in sleep on workdays may have been due to an equal proportion of respondents reporting an increase or decrease in sleep, with the majority reporting no change. Recent studies of sleep across the general population during the pandemic also highlight subpopulations that have been negatively or positively affected.¹⁸ Examination of sleep patterns broken down by seat position and operations in our data did not appear to reveal further insight into these subpopulations. A larger sample size is needed to drill down into other demographics such as employment status (e.g., only 4% of our sample reported being furloughed).

Despite only subtle changes in sleep duration in late 2020, sleepiness was increased in approximately one-third of respondents during days off and half of respondents during flight. This increased sleepiness despite little change in sleep duration may be due to reduced sleep quality and increased mental exhaustion due to increased stress and distractions reported by pilots. The subset of respondents in early 2021 reported a return to pre-pandemic sleepiness levels, suggesting that there may be a trend toward improved alertness as the impact of the pandemic wanes. Follow-up surveys are needed, however, to capture evolving fatigue risk factors.

Pilots reported using the same types of in-flight sleepiness countermeasures prior to and during the pandemic, and at the same frequency. Caffeine was the most popular and most frequently used countermeasure. Moving around and standing up was also a commonly used countermeasure, and increased use of automation was also frequently used. This latter countermeasure may be counterproductive based on a study from our group which shows that latent sleepiness is unmasked when automation is used compared to manual control of a vehicle.¹⁵ How this finding extends to aviation systems is worthy of further research to determine whether reliance on automation is an effective countermeasure to fatigue.

An unexpected finding from this survey was the impact of access to food and exercise during a duty day or layover. These factors outweighed any other theme in the first survey comments in late 2020 and were, therefore, further explored and quantified in the follow-up survey in early 2021. While there is substantial evidence that sleep loss can affect food choices, metabolism, and hormones regulating appetite,²⁰ very little research has approached this as a bidirectional relationship to investigate the impact of food restriction on subsequent sleep. Studies of fasting during Ramadan show changes in sleep duration and architecture, but these changes may be due to shifting mealtimes, rather than a reduction in total caloric

intake.^{1,13} Further research is needed in this area. The impact of exercise on sleep has shown mixed results, with the benefits depending on timing and intensity. While avoiding high intensity exercise close to bedtime is recommended for some individuals, high intensity exercise at other times of day, or low intensity exercise closer to bedtime is typically associated with better sleep outcomes.¹⁰ According to respondents, going to bed hungry, and without the chance to unwind or to maintain physical fitness, impacted their sleep quality and their ability to perform their job safely. Additionally, sleep opportunities were truncated while pilots were trying to find food options both before and after shifts. As regulations relax and allow for the reopening of restaurants and hotels, these issues may passively resolve. However, at the time of writing (October–November 2021), personal correspondence with pilot representatives suggest that these issues are still at the forefront of pilot complaints. Further, providing pilots with guidance on exercise opportunities that can be achieved without the use of gym equipment may be prudent.

Pilots reported that stress from multiple facets of the pandemic, ranging from job insecurity to COVID-19-related health concerns, negatively affected their ability to get good quality sleep and to perform their job safely. While other surveys of pilot well-being during the pandemic (mid-2020) also highlighted the impact of COVID-19 on all facets of mental health,^{6,9} we are the first to report its direct impact on sleep, with 43% reporting that their sleep was affected sometimes or almost always by stress related to health concerns. Cahill and colleagues⁶ reported that 25% of their sample felt their competence to do their job safely had deteriorated during the pandemic, compared to over half our sample reporting that health-related stress had affected their ability to do their job safely at least once or twice in the past month. Therefore, stress is having a significant impact not only on pilot well-being, but perceived job performance as well.

Common techniques for managing stress include maintaining a healthy diet, getting proper exercise, socializing, and relaxation techniques.⁷ The concomitant reduction in the opportunity to promote these other healthy lifestyle factors is likely to exacerbate stress. In addition, pilots have reported not being offered support from their company, losing trust in management, and feeling less valued since the pandemic.^{6,9} EASA's recommendation at the start of the pandemic preempted these outcomes and highlighted the importance of supporting crewmembers during this difficult time.¹¹

It is not just pilots that are affected by the pandemic, but all airline personnel. Indeed, other sectors may be even more affected.⁶ A survey of cabin crew found that depression, stress, and anxiety increased from May 2019 to April 2020.¹⁷ Interestingly, those who were furloughed showed higher levels of depression and stress (e.g., stress of loss of income and depression associated with being unemployed), while those still working showed higher levels of anxiety (e.g., anxiety about getting sick, dealing with passengers). Only 4% of our survey population reported being furloughed compared to an estimated 17% globally,⁹ so we were unable to explore these differences. Of note, we did not specifically ask about

voluntary leave, which may have captured another dimension of employment status. The cabin crew survey highlights that while it is important to consider the mental health and wellbeing of active crewmembers, those furloughed may have unique issues that will need to be managed for return to service. Further, maintenance crews may be uniquely impacted by return to service operations as returning aircraft to service that have been in storage will require a substantial amount of work.¹¹ Careful planning of schedules to avoid fatigue, acknowledgment of changes in the pilot-management trust relationship, and recognizing the need to support unique mental health profiles will be necessary to help promote return to service across an organization.

As observed in other surveys of crew employment status, first officers were more affected than captains in terms of displacement. The pandemic has had an uneven impact on junior careers and led to disillusionment in this demographic with nearly one-quarter of North American pilots reporting they would not choose to be a pilot if they could start again.⁹ In the current situation, pilots flying unfamiliar aircraft, routes, and performing varied tasks is likely to increase risk.^{12,19} Our data suggest that these displacements and furloughs have slowed, but the recovery of the airline industry to prepandemic levels is estimated to take 2–3 yr.⁹ As passenger numbers grow, it is important to re-employ and retrain a workforce in anticipation of, not in reaction to, this growth so that the current workforce is not stretched beyond capacity.

Although this survey included a large sample size and longitudinal data to capture multiple time points across this dynamic time, it is not without limitation. Firstly, the follow-up study did not capture as many respondents as planned, which terminated the longitudinal component of the study prematurely. Secondly, the retrospective nature of the survey questions may have introduced recall bias.

The pandemic has had a significant impact on a wide range of factors in the aviation industry, including pilot fatigue. Increased sleepiness both on the flight deck and on days off may be the result of continued additional pressure from reduced access to essential needs (e.g., nutrition and exercise) and increased stress and distractions and their subsequent effects on sleep quality. As the impact of the pandemic wanes and services return to capacity, it is important to address the cumulative toll of poor sleep and strained mental health in this community.

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